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Benefits of MicroStar M/H 13/15/18's Asymmetric RF Combiner to the Availability and Performance of Protected Millimeterwave Links

Purpose

MicroStar M/H 13/15/18 GHz digital radios use a 2/7 dB asymmetrical (unequal split) RF combiner at each end of a millimeterwave link to provide protection from E1 data interruptions and outages due to equipment failures. It is the purpose of this technical overview to show the benefits of this asymmetrical RF combiner over 3.5/3.5 dB symmetrical (equal split) RF combiners to the link's availability (reduction in long-term rain outage) and performance (reduction in short-term multipath outage).

Overview

Asymmetrical RF combiners are assigned to protected (hot standby) digital microwave links to provide the higher system gain necessary to best meet the user's multipath performance and rain availability objectives. The following table shows that system gains for protected MicroStar M/H radios with equal split RF combiners are about 3 dB lower compared to unequal split combiners during normal (non-failed) equipment operation periods.

MicroStar M/H also exhibits system gains 7-9 dB higher than MicroStar L radios for similar data transport capacities.

SYSTEM GAINS, dB		Assymetrical (Unequal Split) RF Combiner		Symmetrical (Equal Split) RF Combiner	
MicroStar L 15 FSK	1+0	1+1 **A-A**	1+1 **A-B & B-A**	1+1 **A-A**	1+1 **A-B & B-A**
4E1	97	95	88.5		
16E1	93	91	84.5		
MicroStar M/H 15 QPSK	1+0	1+1 **A-A**	1+1 **A-B & B-A**	1+1 **A-A**	1+1 **A-B & B-A**
4E1	108	104	99	101	101
16E1	102	98	93	95	95

A-B = Ch. A Tx on line at Site 1 and Ch. B Rx on line at Site 2 (Ch. A Receiver has failed)
B-A = Ch. B Tx on line at Site 1 and Ch. A Rx on line at Site 2 (Ch. A Transmitter has failed)

Rain Availability Calculations, Normal Operation (Non-Failed Transmitter and Receiver)

The selection of asymmetrical (unequal split) vs. symmetrical (equal split) RF combiners has no effect upon the equipment availability ("uptime") of a millimeterwave microwave link. However, the loss of 3 dB in system gain with symmetrical (equal split) combiners will significantly increase rain outage for more traffic disconnects ("downtime") as well as the numbers and durations of short-term multipath fade outages.

The following are computed from the internationally recognized ITU-R Rec. P.530-8 and R. K. Crane rain outage models. These calculations show that the 3 dB loss of fade margin caused by the assignment of equal loss RF couplers in a typical 15 GHz 10 km link deployed in Malaysia will increase annual rain outage by 19.2% if a V-pol (vertically polarized) path, and 17.8% if H-pol. The R. K. Crane rain outage model computes higher 30.2% and 25.7% increases in rain outage for V-pol and H-pol respectively for this 3 dB loss of rain fade margin.

The following calculations are for a 15 GHz 10 km MicroStar M/H 15 GHz QPSK path deployed in the ITU-R "P" rain rate region for Malaysia ($R_{0.01\%}$ = 145 mm/hr rain rate).

1. ITU-R Rec. P.530-8 Model, V-pol (α = 0.033, β = 1.128) Calculations

- 50 dB rain fade margin: 1654 SES/yr rain outage (99.99475% rain availability)
- 47 dB rain fade margin: 1971 SES/yr rain outage (99.99374% rain availability)

Increase in outage time with a 3 dB loss of fade margin with equal loss splitters: 317 SES/yr (+19.2%)

2. ITU-R Rec. P.530-8 Model, H-pol (α = 0.037, β = 1.154) Calculations

- 50 dB rain fade margin: 3241 SES/yr rain outage (99.98971% rain availability)
- 47 dB rain fade margin: 3817 SES/yr rain outage (99.98788% rain availability)

Increase in outage time with a 3 dB loss of fade margin with equal loss splitters: 576 SES/yr (+17.8%)

3. R. K. Crane Model, V-pol (α = 0.033, β = 1.128) Calculations

- 50 dB rain fade margin: 2762 SES/yr rain outage (99.99123% rain availability)
- 47 dB rain fade margin: 3596 SES/yr rain outage (99.98858% rain availability)

Increase in outage time with a 3 dB loss of fade margin with equal loss splitters: 834 SES/yr (+30.2%)

4. R. K. Crane Model H-pol (α = 0.037, β = 1.154) Calculations

- 50 dB rain fade margin: 6362 SES/yr rain outage (99.97980% rain availability)
- 47 dB rain fade margin: 7996 SES/yr rain outage (99.97462% rain availability)

Increase in outage time with a 3 dB loss of fade margin with equal loss splitters: 1634 SES/yr (+25.7%)

Availability Calculations, Abnormal Operation (Failed “A” Transmitter or Receiver)

The very infrequent failure of an on-line main (“A”) transmitter or main (“A”) receiver initiates a data switch from the on-line “A” transmitter or “A” receiver to the “B” radio, thus lowering the fade margin of a MicroStar M/H link 5 dB during the MTR (“Mean Time to Restore” service) duration of the repair period. The switching of the DADE (aligned) data to and from the “B” standby transmitter and receiver is typically errorless.

This 5 dB reduction in fade margin is very infrequent and highly unlikely to coincide with a high rain rate period that could cause long-term outage and traffic disconnects, as seen in the following calculations.

The MTBF (“Mean Time Between Failure”) of an unprotected MicroStar M/H link, including its IDU (“Indoor Unit”) and ODU (“Outdoor Unit”) is 150,000 hours. Assuming two different MTR (“Mean Time to Restore” service) periods of 30 minutes and 6 hours respectively, the following intervals between these failure events is computed:

Assumption 1, 30 minute (0.5 hr) MTR (repair time):

This very short MTR = MTTR (Mean Time To Repair or replace the failed module) presumes that an experienced technician is at the site at the time of failure, perhaps at an MSC or other manned site, and has the appropriate replacement module and tools to rapidly complete the task.

The link’s 5 dB reduction in fade margin time, $T_{(-5\ dB)}$, is then computed as follows:

$$T_{(-5\ dB)} = 1 – MTBF/(MTBF + MTR) = 1 – 150{,}000/(150000 + 0.5) = 0.0000033.$$

The annual duration of a 5 dB fade margin degradation is then 0.0000033 x 8760 hr/yr = 0.0292 hours (1.75 minutes). Since the repair time is 30 minutes, this event typically occurs every 30/1.75 = 17 years. The statistical probability of a highly intense rain cell encroaching upon a MicroStar M/H 15 GHz link during this $T_{(-5\ dB)}$ = 30 minute reduced fade margin period is nil.

Assumption 2, 6 hour MTR (repair time):

A 6-hour Mean Time to Restore service is computed based upon the following assumptions:

MTR = MTTR + Diagnostics/Travel Time + Spares (24 hr to obtain a replacement for 5% of the modules)

= 0.5 hr + 4.3 hr + 24x0.05 = 6 hours.

The annual duration of a 5 dB fade margin degradation is now computed to be

$$T_{(-5\ dB)} = 1 – MTBF/(MTBF + MTR) = 1 – 150{,}000/(150000 + 6) = 0.0000400.$$

The annual duration of a 5 dB fade margin degradation is then 0.0000400 x 8760 hr/yr = 0.35 hours (21 minutes). Since the repair time is 6 hours, this event typically occurs every 6/0.35 = 17 years. Again, the likelihood of a highly intense rain cell encroaching upon a MicroStar M/H 15 GHz link during this $T_{(-5\ dB)}$ = 6 hour reduced fade margin period is nil.

Performance Calculations, Normal Operation (Non-Failed Transmitter and Receiver)
The short-term multipath outage for this very short 10 km path with its high 47-50 dB rain fade margins from ITU-R P.530-9 and Vigants' multipath outage model calculations is insignificant (SESR = <0.00000040; outage = <1 SES/any month), so any degradation in the link's error performance due over a short $T_{(-5\ dB)}$ period is disregarded in this analysis.

However, both multipath outage models compute 2X more short-term outage with a 3 dB reduction in fade margin resulting from the deployment of equal loss RF combiners.

Conclusions
The application of a 2/7 dB asymmetrical (unequal loss) RF combiner at each end of a MicroStar M/H 13/15/18 GHz link significantly lowers the annual outage and reduces traffic disconnects due to rain fades as compared to millimeterwave links deployed with symmetrical (equal loss) RF combiners.

A temporary 5 dB reduction in rain fade margin typically occurring with an on-line "A" Tx or on-line "A" Rx failure event at 17-year intervals has no affect upon digital microwave link and network unavailability ("downtime"). The probability of a significant rain fade occurring during a 0.5-6 hour repair time to restore the radio to its normal Transmitter "A" and Receiver "A" on-line status is insignificant. .

And MicroStar M/H's much higher system gain, 5-7 dB more than a MicroStar L link with equal data throughput for example, will further increase link availability (circuit "uptime"), extend path lengths, and reduce antenna sizes as compared to other millimeterwave digital microwave radios.